TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

IEC
CEI

TS 60479-2

Third edition
Troisième édition
2007-05

Effects of current on human beings and livestock –

Part 2: Special aspects

Effets du courant sur l'homme et les animaux domestiques –

Partie 2: Aspects particuliers

Reference number
Numéro de référence
IEC/CEI/TS 60479-2:2007

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm
Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub
Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

IEC CEI TS 60479-2

Third edition
Troisième édition
2007-05

Effects of current on human beings and livestock –

Part 2: Special aspects

Effets du courant sur l'homme et les animaux domestiques –

Partie 2: Aspects particuliers

Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE
CODE PRIX W

For price, see current catalogue
Pour prix, voir catalogue en vigueur

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 2: Special aspects

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60479-2, which is a technical specification, has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This third edition cancels and replaces the second edition, published in 1987, and constitutes a technical revision.

The major changes with regard to the previous edition are as follows:

– The report has been completed with additional information on effects of current passing through the human body for alternating sinusoidal current with d.c. components, alternating sinusoidal current with phase control, alternating sinusoidal current with multicycle control in the frequency range from 15 Hz up to 100 Hz.
– An estimation of the equivalent current threshold for mixed frequencies.
– The effect of repeated pulses (bursts) of current on the threshold of ventricular fibrillation.
– Effects of electric current through the immersed human body.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
64/1544/DTS	64/1579/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60479 series, under the general title *Effects of current on human beings and livestock*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

EFFECTS OF CURRENT ON HUMAN BEINGS AND LIVESTOCK –

Part 2: Special aspects

1 Scope

IEC 60479-2, which is a technical specification, describes the effects on the human body when a sinusoidal alternating current in the frequency range above 100 Hz passes through it.

The effects of current passing through the human body for

– alternating sinusoidal current with d.c. components,
– alternating sinusoidal current with phase control,
– alternating sinusoidal current with multicycle control,

are given but are only deemed applicable for alternating current frequencies from 15 Hz up to 100 Hz.

NOTE 1 Other waveforms are under consideration.

This standard furthermore describes the effects of current passing through the human body in the form of single unidirectional rectangular impulses, sinusoidal impulses and impulses resulting from capacitor discharges.

NOTE 2 The effects of sequences of impulses are under consideration.

The values specified are deemed to be applicable for impulse durations from 0,1 ms up to and including 10 ms. For impulse durations greater than 10 ms, the values given in Figure 20 of IEC 60479-1 apply.

This standard only considers conducted current resulting from the direct application of a source of current to the body, as does IEC 60479-1 and IEC 60479-3. It does not consider current induced within the body caused by its exposure to an external electromagnetic field.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60479-1:2005, *Effects of current on human beings and livestock – Part 1: General aspects*

IEC 60479-3, *Effects of current on human beings and livestock – Part 3: Effects of currents passing through the body of livestock*

IEC 60990, *Methods of measurement of touch current and protective conductor current*

3 Terms and definitions

For the purposes of this document, the following definitions, in addition to those given in IEC 60479-1, apply.

NOTE Certain definitions are taken from the IEV. Such references are listed in the bibliography [27], [28] [1].

3.1
frequency factor
F_f
ratio of the threshold current for the relevant physiological effects at the frequency f to the threshold current at 50/60 Hz

NOTE The frequency factor differs for perception, let-go and ventricular fibrillation.

3.2
phase control
process of varying the instant within the cycle at which current conduction in an electronic valve device or a valve arm begins

(IEV 551-16-23)

3.3
phase control angle (current delay angle)
time expressed in angular measure by which the starting instant of current conduction is delayed by phase control

(IEV 551-16-32)

3.4
multicycle control
process of varying the ratio of the number of cycles which include current conduction to the number of cycles in which no current conduction occurs

(IEV 551-16-31)

3.5
multicycle control factor
p
ratio between the number of conducting cycles and the sum of conducting and non-conducting cycles in the case of multicycle control

(IEV 551-16-37) (and see Figure 12 in this standard)

3.6
specific fibrillating energy
F_e (Ws/Ω or A^2s)
minimum $I^2 \cdot t$ value of a unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

NOTE F_e is determined by the form of the impulse as the integral

$$\int_0^{t_i} i^2 dt$$

where t_i is defined in Figures 17 and 18. F_e multiplied by the body resistance gives the energy dissipated in the human body during the impulse.

3.7
specific fibrillating charge
F_q (C or As)
minimum $I \cdot t$ value of unidirectional impulse of short duration which under given conditions (current-path, heart-phase) causes ventricular fibrillation with a certain probability

---

1) References in square brackets refer to the bibliography.

NOTE F_q is determined by the form of the impulse as the integral

$$\int_0^{t_i} i dt$$

Where t_i is defined in Figures 17 and 18.

3.8
time constant
time required for the amplitude of an exponentially decaying quantity to decrease to

$$\frac{1}{e} = 0{,}3679$$

times an initial amplitude

(IEV 801-21-45, modified)

3.9
shock duration of a capacitor discharge
t_i
time interval from the beginning of the discharge to the time when the discharge current has fallen to 5% of its peak value (see Figures 17 and 18)

NOTE When the time constant of the capacitor discharge is given by T, the shock duration of the capacitor discharge is equal to $3T$. During the shock duration practically all the energy of the impulse is dissipated.

3.10
shock duration for complex asymptotic waveform
t_i
shortest duration of that part of the impulse that contains 95 % of the energy over the total impulse

3.11
threshold of perception
minimum value for the charge of electricity which under given conditions causes any sensation to the person through whom it is flowing

3.12
threshold of pain
minimum value for the charge ($I \cdot t$) or specific energy ($I^2 \cdot t$) that can be applied as an impulse to a person holding a large electrode in the hand without causing pain

3.13
pain
unpleasant experience such that it is not readily accepted a second time by the subject submitted to it

NOTE Example are an electric shock above the threshold of pain described in 11.3, the sting of a bee or burn of a cigarette.

4 Effects of alternating currents with frequencies above 100 Hz

NOTE Values for 50/60 Hz are given in IEC 60479-1.

4.1 General

Electric energy in the form of alternating current at frequencies higher than 50/60 Hz is increasingly used in modern electrical equipment, for example aircraft (400 Hz), power tools and electric welding (mostly up to 450 Hz), electrotherapy (using mostly 4 000 Hz to 5 000 Hz) and switching mode power supplies (20 kHz to 1 MHz).

Little experimental data is available for this clause, so that the information given herein should be considered as provisional only but may be used for the evaluation of risks in the frequency ranges concerned (see bibliography). Attention is also drawn to the fact that the impedance of human skin decreases approximately inversely proportional to the frequency for touch voltages in the order of some tens of volts, so that the skin impedance at 500 Hz is only about one-tenth of the skin impedance at 50 Hz and may be neglected in many cases. This impedance of the human body at such frequencies is therefore reduced to its internal impedance Z_i (see IEC 60479-1).

NOTE **The use of peak measurements**. At current levels that produce physiological responses of perception, startle reaction and inability of let-go, the physiological response from non sinusoidal and mixed frequency periodic current is best indicated by the peak value of an output signal from measuring circuits containing a frequency-weighting network such as those described in IEC 60990.

These frequency weighting networks attenuate the signal according to the frequency factors of Clause 4 of IEC 60479-1 so that the output signal corresponds to a constant level of physiological response. Attenuation is provided for narrow impulses of current that would produce less physiological response because of the short duration of their peak value. The network output allows a fixed value to be read independent of waveshape or mix of frequencies to be provided for ease of determination of the leakage current and evaluation of the level of hazard present.

Comparable physiological effects are produced by non sinusoidal and sinusoidal current producing the same peak value by this measurement method.

Representative network can be found in IEC 60990 and in bibliographic reference [16].

4.2 Effects of alternating current in the frequency range above 100 Hz up to and including 1 000 Hz

4.2.1 Threshold of perception

For the threshold of perception the frequency factor is given in Figure 1.

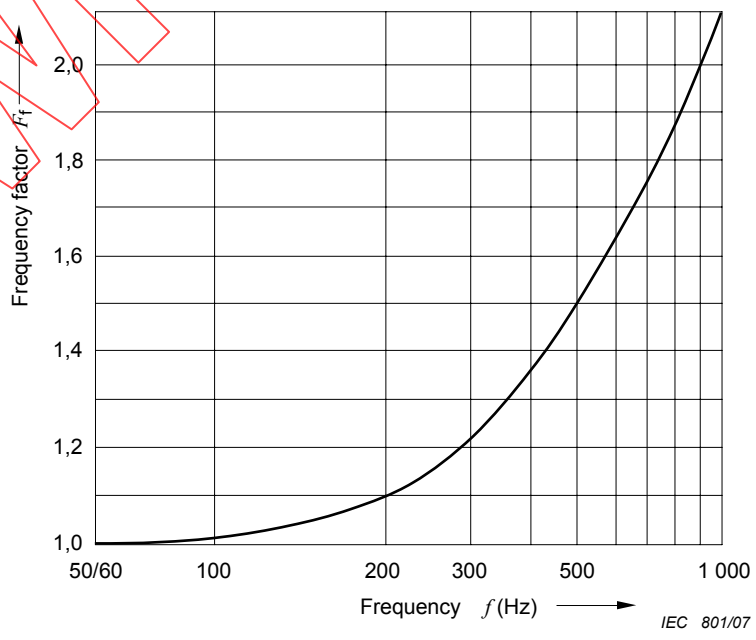

Figure 1 – Variation of the threshold of perception within the frequency range 50/60 Hz to 1 000 Hz

4.2.2 Threshold of let-go

For the threshold of let-go the frequency factor is given in Figure 2.

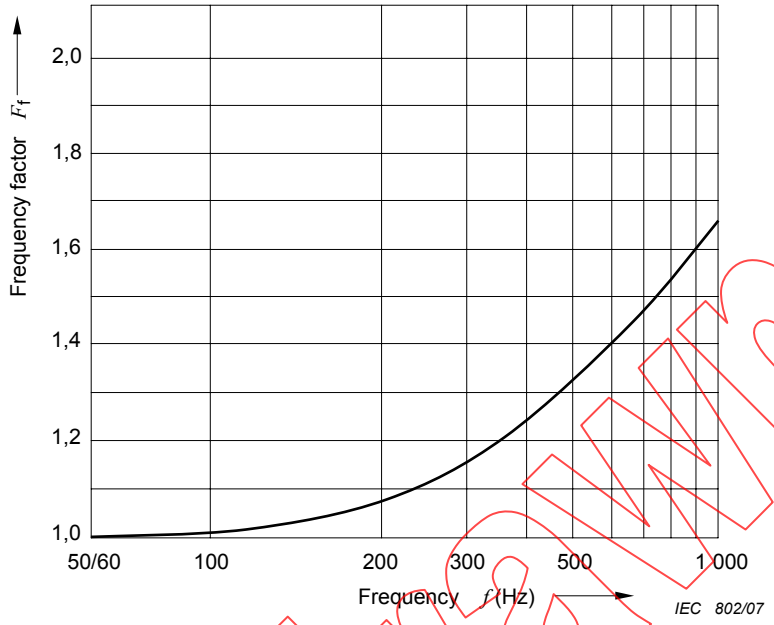

Figure 2 – Variation of the threshold of let-go within the frequency range 50/60 Hz to 1 000 Hz

4.2.3 Threshold of ventricular fibrillation

For shock durations longer than the cardiac cycle, the frequency factor for the threshold of fibrillation for longitudinal current paths through the trunk of the body is given in Figure 3.

For shock durations shorter than the cardiac cycle no experimental data is available.

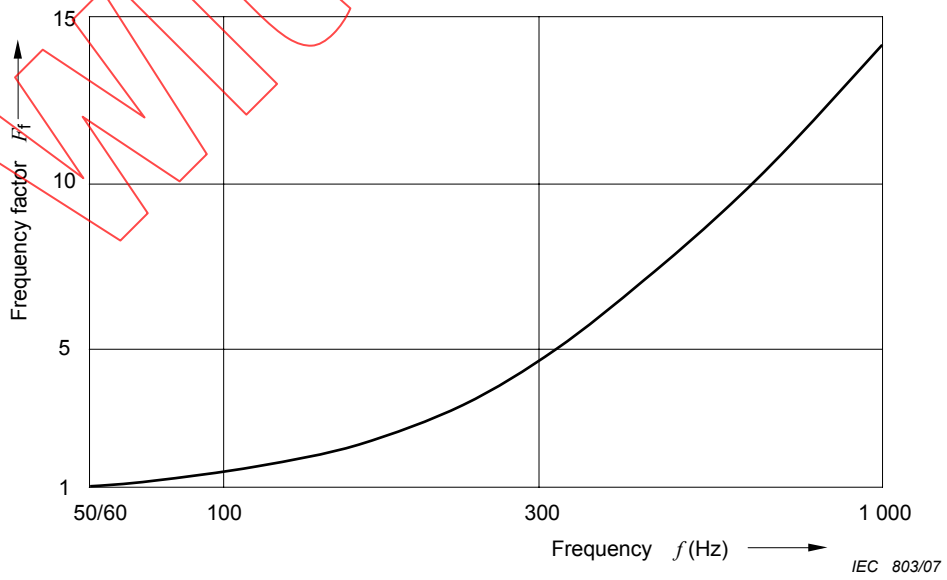

Figure 3 – Variation of the threshold of ventricular fibrillation within the frequency range 50/60 Hz to 1 000 Hz, shock durations longer than one heart period and longitudinal current paths through the trunk of the body

4.3 Effects of alternating current in the frequency range above 1 000 Hz up to and including 10 000 Hz

4.3.1 Threshold of perception

For the threshold of perception the frequency factor is given in Figure 4.

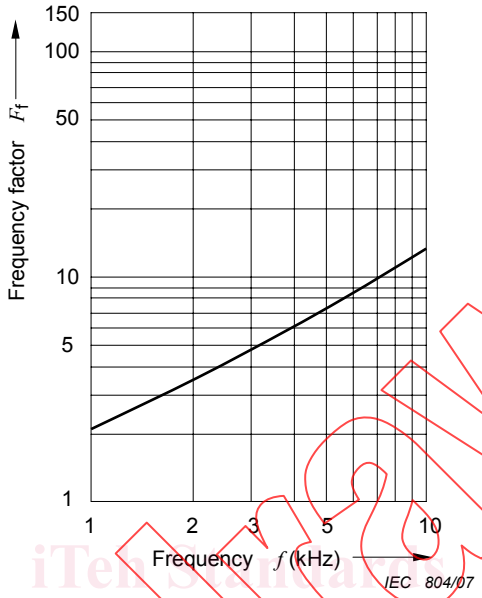

Figure 4 – Variation of the threshold of perception within the frequency range 1 000 Hz to 10 000 Hz

4.3.2 Threshold of let-go

For the threshold of let-go the frequency factor is given in Figure 5.

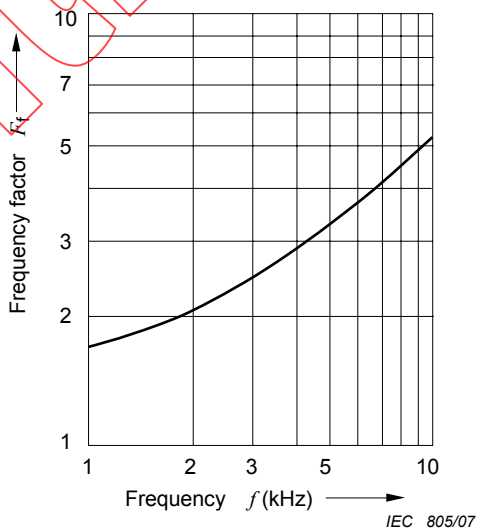

Figure 5 – Variation of the threshold of let-go within the frequency range 1 000 Hz to 10 000 Hz

4.3.3 Threshold of ventricular fibrillation

Under consideration.